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COMMITTEE ON FIRE TOXICOLOGY SIX-MONTH
PROGRESS REPORT

NATIONAL ACADEMY OF SCIENCES-NATIONAL RESEARCH
COUNCIL, WASHINGTON, D.C.

JULY 1976

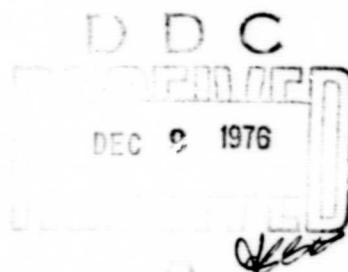
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SIX-MONTH PROGRESS REPORT

Committee on Fire Toxicology

Assembly of Life Sciences
National Research Council

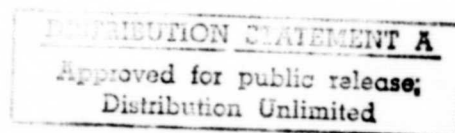


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NOTICE

The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

0718

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the National Academy of Sciences, Advisory Center
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Committee on Fire Toxicology

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SIX-MONTH PROGRESS REPORT
THE COMMITTEE ON FIRE TOXICOLOGY

At the request of the National Aeronautics and Space Administration, the Committee on Fire Toxicology has undertaken the task of reviewing the state-of-knowledge and methodology for testing the toxicity of polymeric materials in fires on aircraft, spacecraft and other transportation systems. Zapp *et al.*²² reported on the toxicity of pyrolysis products as early as 1955. Numerous reports have been published on the toxicity of pyrolysis/combustion products and on methodology; however, most of these methods were designed for research and were not intended to be applicable for use as screening methods. A review of the methodologies used to study toxicities of combustion products of polymeric materials soon will be completed by this committee.¹⁻²¹

Based on the literature review, presentations at the International Symposium on Toxicity and Physiology of Combustion Products, University of Utah, March 22-26, 1976, and presentations made to the Committee on April 7, 1976,* the Committee observes that acceptable screening tests to evaluate the relative toxicities of aircraft materials are not currently available, as all present methods have one or more shortcomings.

The Committee considers the following to be requirements for an optimum screening test for toxicity:

- a. Materials should be evaluated under both pyrolysis and flaming modes. Two heat fluxes should be used for pyrolysis; one flux should be just below that which would produce flaming combustion, and the other should be just higher than the temperature at which pyrolysis starts. These burn conditions necessitate the evaluation of each material at three heat fluxes. The samples should be exposed to known heat fluxes; however, it is highly desirable to measure the surface temperature of the sample during combustion. Both gaseous and particulate combustion products should be mixed uniformly in the chamber atmosphere without being unduly subjected to surface condensation or adsorption.
- b. The time of pyrolysis or combustion should be short compared with the animal exposure time.

* Presentations were made by M.M. Birky, National Bureau of Standards; C.R. Crane, Federal Aviation Administration; H.H. Cornish, University of Michigan; D.P. Dressler, Harvard Medical School; R. Long, Natl. Fire Prevention and Control Administration; J. H. Petajan, University of Utah; and W.H. Rippstein, NASA

- c. It is highly desirable to use one chamber for both combustion/pyrolysis and animal exposure. This not only approximates the real fire situation but prevents large losses of combustion particles and gases on the walls of any transfer apparatus. The animals must be protected from direct radiation from the burning material or the hot gases. This may be done with a radiation barrier and a satisfactory mixing device. The chamber should be airtight to prevent toxic gases from leaking into the laboratory; however, there should be a safety pressure relief diaphragm. The system must be easy to clean between runs.
- d. A small rodent species such as the rat or mouse should be used as the animal model. Enough animals must be used at each exposure condition to give statistically valid results.
- e. The exposure time should be in the range of 15-30 minutes, preferably 30 minutes. Exposure time should begin at the time pyrolysis or combustion products are released.
- f. The temperature in the animal chamber should not exceed 35°C; however, the best means for controlling temperature has not been determined.
- g. Incapacitation was considered to be the most important endpoint since it should be directly related to escape capability. The committee members have not yet agreed on the type of measurement to make. The shuttle box, running wheel, and leg-flexion paradigms were discussed. It was recommended that research should be conducted to compare methods for assessing incapacitation endpoints. Experimental animals should be held for 2 weeks post exposure and the number of deaths recorded. Visual observations of animal behavior and physical condition during and after exposure are considered extremely important; thus these should be done by a qualified investigator. Some type of quantitative test may be required to evaluate observations made by the investigator. Carboxy-hemoglobin should be measured in the animal at the end of the exposure. It is also highly desirable to measure the respiration rate and other physiologic parameters in at least one animal during the exposure. The smoke density in the animal chamber should be measured during the animal exposure.

- h. In addition to temperature, carbon monoxide, carbon dioxide, humidity, and oxygen levels should be monitored in the chamber during animal exposure. The oxygen should be maintained above 16%. Other expected toxic degradation products such as hydrochloric acid or hydrogen cyanide should be monitored.
- i. The amount of material combusted or pyrolyzed within the chamber should be determined. Dose should be expressed in mg/m^3 and should give an endpoint in 30 minutes.
- j. Relative toxicity of materials should be determined by comparing test materials with reference materials, those in use or candidate materials, rather than attempting to make absolute toxicity evaluations.

Most current procedures for determining the toxicity of combustion products involve the transfer of the products; therefore, they do not meet requirement c. The official testing methods of Germany¹² and Japan¹³ involve the transfer of combustion products and use combustion tubes rather than a radiant heat source. The method of Smith *et al.*²⁰ involves such a short transfer of gases that it may be interpreted to fulfill the requirement of not transferring combustion products; however, this procedure does not make use of a radiant heat source. The apparatus in use at the University of Utah^{7,16} probably comes closest to meeting the equipment parameters outlined above; however, the number of animals exposed at one time should be increased.

The optimum screening test for toxicity in this progress report will require the development of a prototype test apparatus and experimental validation of the foregoing parameters for sensitivity and reproducibility. It is suggested that NASA may wish to consider the requirements listed above in setting up their evaluations of the toxicities of aircraft materials subjected to fire.

The Committee will require additional time for the preparation of a formal report. The report will include a detailed review of currently used methods for fire-toxicity testing and more detailed description of the optimum toxicity screening test. The test parameters may be modified after further study by the Committee.

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